IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	**Boudouris et al**
Application No.:	**09/990109**
Filed:	**November 21, 2001**
For:	**Magnetic Substrates, Composition and Method for Making the Same**
Group Art Unit:	**1733**

Mail Stop ________
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Docket No.: M112.2-10064-US01

DECLARATION UNDER 37 C.F.R. §1.132

SUPPLEMENTAL BOUDOURIS DECLARATION

I, Randall Boudouris, coinventor of the above referenced patent application and of the subject matter described and claimed therein, attest and say as follows:

1. I, have previously provided a declaration in this case, dated 5-28-2004 in which my background is provided. I am informed that my previous declaration has a USPTO mailroom date of 6-10-2004. This declaration is submitted to supplement my previous declaration.

2. On August 10, 2005 I, together with attorneys Richard Arrett and Lisa Ryan-Lindquist and coinventor Ray Richards participated in a telephone interview with Examiner Gladys Corcoran. During the interview, a new reference, U.S. Patent No. 6,881,450 to Texier, issued April 19, 2005 was discussed. The Examiner contended that this reference suggests to use a composition having as much filler as possible, including 80%. Based on my experience and my knowledge of the equipment described for application of the Texier compositions I am of the opinion that the Examiner's contention is clearly incorrect.

3. At col. 4, lines 34-39, the Texier patent teaches applying his composition with a Nordson 3960 Multiscan machine. That machine cannot handle the compositions defined in our claim. Attached as Exhibit A is a Nordson Corporation brochure, *Technical Data for Series 3960 Melters.* On page D 1-1, it states that the maximum viscosity which can be accommodated by the 3960 Melter is 30,000 CPS and the maximum temperature is 450°F. Also on that page the Pump specifications are given, all of which are ¾ hp DC Gear pumps. From this information it is clear that the machines taught by Texier are not extruders. Gear pumps do not induce a high shear rate and cannot apply a composition as claimed in our application.

4. To illustrate the especially high viscosity of our compositions, after the August 10, 2005 interview with Examiner Gladys I submitted three samples to the Polymer Processing Institute at the New Jersey Institute of Technology for characterization of the melt viscosity properties of the formulations. The formulations used an ethylene vinyl acetate polymer (EVA, 400 Melt Index, 28% vinyl acetate) in three compositions as follows:

(1) 100% EVA
(2) EVA/Ferrite Pellets @ 85% ferrite/15% EVA blend.
(3) 75% ferrite/25% EVA.

5. Attached as Exhibit B is a letter from Dr Victor Tan, Manager, Polymer Characterization Lab at the Polymer Processing Institute, reporting the results of his characterization measurements. The data was taken at 230 °C, the maximum SI unit operating temperature identified in on page D-1 of Exhibit A. Since melt viscosities of thermoplastic polymers decrease with temperature, the compositions will display their minimum viscosities for purposes of the Texier patent.

6. The apparent viscosity and true viscosity obtained for formula (1) at various shear rates in reciprocal seconds (sec^{-1}), are found in Table 1 and plotted in Figure 1 of Exhibit B.

7. The apparent viscosity and true viscosity obtained for formula (2) are found in Table 2 and plotted in Figure 2 of Exhibit B.

8. The apparent viscosity and true viscosity obtained for formula (3) are found in Table 3 and plotted in Figure 3 of Exhibit B.

9. Figure 4 of Exhibit B plots the true viscosity of each of the three materials at the various shear rates tested to allow direct comparison.

10. All samples exhibit Newtonian fluid behavior and are therefore shear rate dependent.

11. The viscosity of sample (1) under even the lowest shear condition (70 sec^{-1}) is approximately 13 Pa-s or 13,000 cPs. At higher shear rates the viscosity drops. Therefore there is no doubt that the EVA polymer is suitable for delivery in the Nordson 3960 Melter.

12. The viscosity of sample (3), the 75% ferrite sample was well above the 30,000 cps limit the Nordson 3960 Melter , except at the two highest shear rates tested, both of which cannot be obtained with the Nordson ¾ hp DC Gear pumps.

13. The viscosity of sample (2), a formulation of the invention as presently claimed, was double the maximum viscosity usable in the Nordson 3960 melter even at the highest shear rate tested. By extrapolation between samples 3 and 2, a sample having 80% ferrite/20% EVA would also be too high in viscosity for the Nordson 3960 Melter.

14. In the adhesive application art it is generally known that materials containing abrasive fillers or highly filled materials should not be run in machines which use a gear pump. See Exhibit C, Handbook of Adhesives, Third Edition, Skeist, Irving, ed., Van Norstrand Reinhold (1990), Chapter 46, pages 736-737, at 737, and Exhibit D, A.

Webber, "Mix & Match", Assembly Magazine 2/1/2001, (printed from http://www.assemblymag.com), at p. 6.

15. Ferromagnetic particulate materials are abrasive. At the time of our invention, use of hot melt compositions having high concentrations of ferromagnetic particulate materials in accordance with the disclosure found in the Texier patent would already have been expected to present significant problems in maintaining the application equipment in operating condition. In view of the information presented herein and in light of my experience in the industry, it is my opinion that use of particle levels higher than the 75% composition identified in the Texier patent would not have been expected by the person of ordinary skill in the art to be operable, both because such materials have too high a viscosity for the application equipment and because they would have been expected to significantly damage the application equipment.

16. All statements made herein of my own knowledge are true; all statements made on the information and belief are believed to be true; and all the foregoing statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment or both, under § 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of this application and any registration resulting therefrom.

Date: 9-6-05 Signed: Randall Boudouris

Randall Boudouris

Part D, Section 1

Technical Data for Series 3960 Melters

This section covers the following unit configurations.	
Model	3960
Voltage	All
Pump	All
Manifold	All
Control	All

Section D 1
Technical Data for Series 3960 Melters

1. Specifications

Viscosity Range	800–30,000 CPS
Ambient Temperature Range	0–50 °C (32–120 °F)
Operating Temperature Range	70–230 °C (160–450 °F)
Temperature Control Stability	± 0.5 °C (± 1 °F)
Tank Volume	32.4 l (1980 cu. in.)
Tank Capacity	31.8 kg (70 1b)
Melt Rate	45.5 kg/hr (100 lb/hr)
Hose/Gun Usage	2,4,6
Pump Weight	DC Gear Pump 125 kg (275 lb)
Electrical service	200–240 VAC, 50/60 Hz, 3∅, 380–415/220–240 VAC, 50/60 Hz, 3∅
Tank Dimensions	216 x 117 mm (8.50 x 4.62 in.)

Pump Specifications						
Pump Type	**Configure Code**	**Rate**	**Displacement**	**Speed**	**Maximum Working Pressure**	**Air Consumption/ Speed Reduce Ratio**
3/4 hp DC Gear	O	0.82 kg/mi (1.8 lb/min)	6.93 cc/rev. (0.42 in^3/rev.)	146 rpm	82.7 bar (1200 psi)	10:1
3/4 hp DC Gear	R	0.41 kg/mi (0.9 lb/min)	3.47 cc/rev. (0.21 in^3/rev.)	146 rpm	82.7 bar (1200 psi)	10:1
3/4 hp DC Gear	S	0.19 kg/min (0.4 lb/min)	1.34 cc/rev. (0.08 in^3/rev.)	146 rpm	82.7 bar (1200 psi)	10:1
3/4 hp DC Gear	T	0.19 kg/min (0.4 lb/min)	1.34 cc/rev. (0.08 in^3/rev.)	73 rpm	82.7 bar (1200 psi)	20:1
3/4 hp DC Gear	U	0.06 kg/min (0.13 lb/min)	1.34 cc/rev. (0.08 in^3/rev.)	49 rpm	82.7 bar (1200 psi)	30:1
3/4 hp DC Gear	W	0.03 kg/min (0.07 lb/min)	1.34 cc/rev. (0.08 in^3/rev.)	24 rpm	82.7 bar (1200 psi)	60:1

1. Specifications *(contd.)*

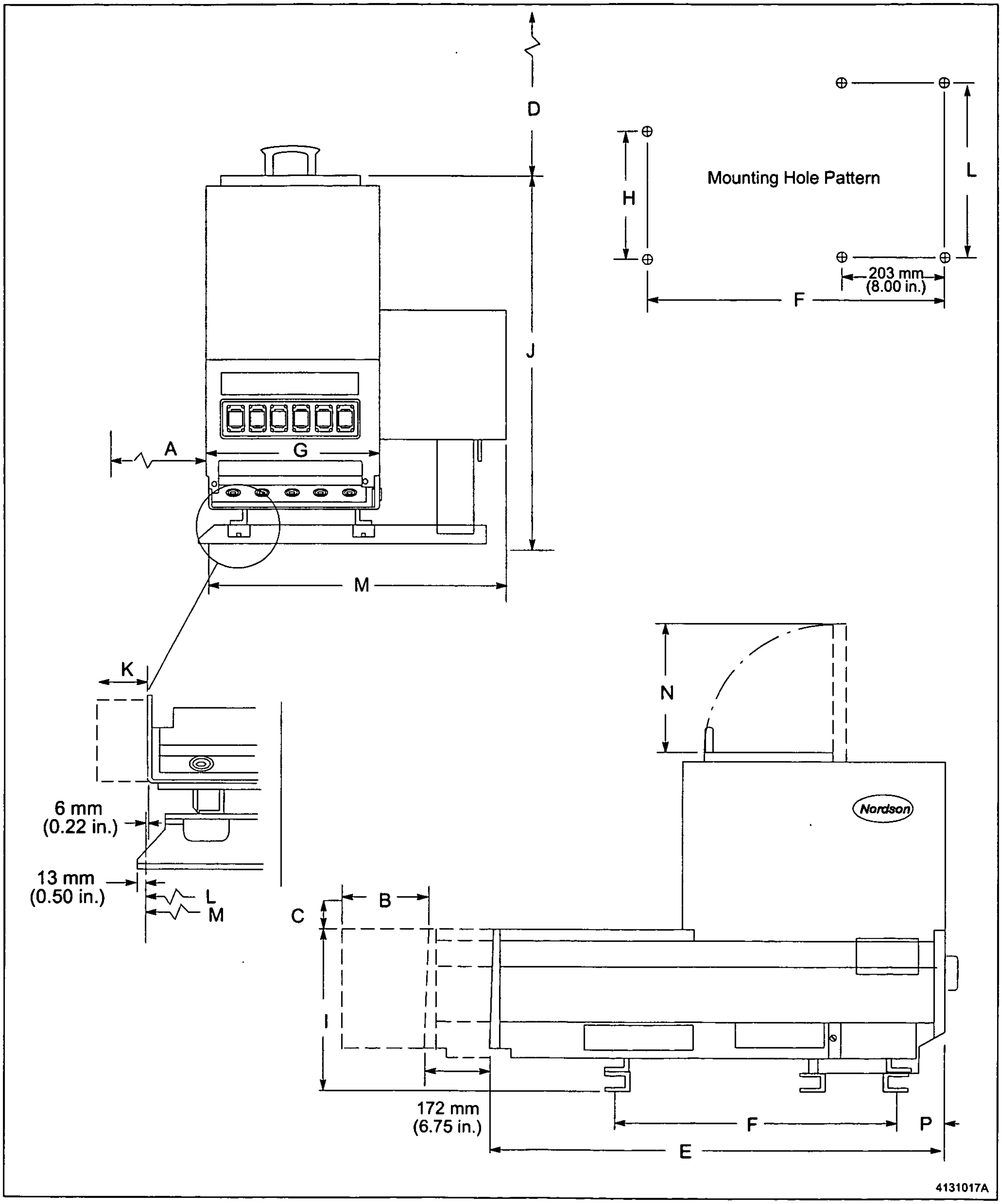

Fig. D 1-1 Series 3960 DC Gear Pump Melters

Melter Model	A (mm/in)	B (mm/in)	C (mm/in)	D (mm/in)	E (mm/in)	F (mm/in)	G (mm/in)	H (mm/in)
3960 PP	330 (13.00)	340 (13.38)	38 (1.50)	418 (16.47)	1071 (42.18)	669 (26.34)	343 (13.50)	249 (9.80)
3960 DC	330 (13.00)	340 (13.38)	38 (1.50)	418 (16.47)	1071 (42.18)	695 (27.39)	343 (13.50)	384 (15.11)
3960 DC, MPC	330 (13.00)	340 (13.38)	38 (1.50)	418 (16.47)	1071 (42.18)	695 (27.39)	343 (13.50)	384 (15.11)
	I (mm/in)	**J (mm/in)**	**K (mm/in)**	**L (mm/in)**	**M (mm/in)**	**N (mm/in)**	**O (mm/in)**	**P (mm/in)**
3960 PP	348 (13.69)	749 (29.50)	54 (2.13)			291 (11.44)	62 (2.44)	110 (4.32)
3960 DC	403 (15.87)	805 (31.68)	54 (2.13)	533 (21.00)	622 (24.50)	291 (11.44)	5 (0.22)	83 (3.26)
3960 DC, MPC	403 (15.87)	805 (31.68)	87 (3.44)	533 (21.00)	622 (24.50)	291 (11.44)	5 (0.22)	83 (3.26)

NOTE: Be sure to provide sufficient clearance room when installing the melter to allow access to the enclosure door, enclosure lid, pump cover and filter assembly.

2. Procedure for Calculating Hose/Gun Capacity

When you connect hoses and guns to your melter, you must make sure the electrical power requirements of those hoses and guns do not exceed the maximum wattages allowed for your system. Exceeding the maximum wattage can damage your equipment.

For every Series 3000 system, there are four maximum wattages you must not exceed:

- **The single-component maximum wattage:** the wattage of any single hose or gun connected to a power module must not exceed this wattage.
- **The hose/gun pair maximum wattage:** the wattage of any hose and gun (hose/gun pair) connected to a power module must not exceed this wattage.
- **The power module maximum wattage:** the wattage of any two hoses and two guns (two hose/gun pairs) connected to a power module must not exceed this wattage.
- **The total hose/gun maximum wattage:** the wattage of all hoses and guns connected to the melter must not exceed this wattage.

To make sure your system does not exceed the maximum allowable wattages, someone (either you or your Nordson representative) must calculate the hose/gun capacity for your system. If your Nordson representative has already made this calculation for the actual hoses and guns you plan to use, you do not need to repeat the calculation now. However, you must make this calculation

- if the hose/gun capacity has not been calculated for your system
- if you have reconfigured your system since the calculations were made
- whenever you add new hoses or guns to an existing system
- whenever you replace an existing hose with a longer one or an existing gun with a larger one

Calculating Hose/Gun Capacity

Follow this procedure whenever you need to calculate the hose/gun capacity for any Series 3000 system.

1. Determine which of the following types of electrical service is connected to your melter:

Type of System	Types of Electrical Service that can be Connected
200 VAC system	200 VAC 1∅ 200 VAC 3∅ (without neutral)
220 VAC system	220 VAC 1∅ 220 VAC 3∅ (without neutral) 380/220 3∅ (with neutral)
230 VAC system	230 VAC 1∅ 230 VAC 3∅ (without neutral) 400/230 3∅ (with neutral)
240 VAC system	240 VAC 1∅ 240 VAC 3∅ (without neutral) 415/240 3∅ (with neutral)
400 VAC system	400 VAC 3∅

2. Use Table D 1-3 and record the wattages in Table D 1-1 for the hoses and guns you wish to connect to your melter. An example is provided as Table D 1-2.

Table D 1-1 Hose/Gun Wattages for Your System

Power Module	**Hose or Gun Zone Number**	**Type of Hose or Gun**	**Wattage of Hose or Gun from Table D 1-3**	**Total Wattages**
Power module 1	Hose 1			
	Gun 1			
	Hose 2			
	Gun 2			
Total wattage for power module 1				
Power module 2	Hose 3			
	Gun 3			
	Hose 4			
	Gun 4			
Total wattage for power module 2				
Power module 3	Hose 5			
	Gun 5			
	Hose 6			
	Gun 6			
Total wattage for power module 3				
Total wattage for all hoses and guns (sum of the total wattage for all power modules)				

Calculating Hose/Gun Capacity (contd.)

EXAMPLE: A Series 3700 6-hose DC gear pump melter is connected to a 240 VAC 3Ø (without neutral) power supply. The user wishes to connect the hoses and guns shown in Table D 1-2.

Table D 1-2 Hose/Gun Wattages for the Example Series 3700 System

Power Module	**Hose or Gun Zone**	**Hose or Gun Type**	**Hose or Gun Wattage from Table D 1-3**	**Total Wattages**
Power module 1	Hose 1	24 ft hose	691 W	974 W
	Gun 1	H-204 gun	283 W	
	Hose 2	24 ft hose	691 W	920 W
	Gun 2	H-202 gun	229 W	
Total wattage for power module 1				**1894 W**
Power module 2	Hose 3	6 ft hose	169 W	398 W
	Gun 3	H-202 gun	229 W	
	Hose 4	10 ft hose	289 W	572 W
	Gun 4	H-204 gun	283 W	
Total wattage for power module 2				**970 W**
Power module 3	Hose 5	24 ft hose	691 W	1131 W
	Gun 5	H-208 gun	440 W	
	Hose 6	24 ft hose	691 W	1131 W
	Gun 6	H-208 gun	440 W	
Total wattage for power module 3				**2262 W**
Total wattage for all hoses and guns (sum of the total wattage for all power modules)				**5126 W**

Table D 1-3 Wattages for Nordson Hoses and Guns

Hose or Gun Type (See Note A)	Type of Electrical Service Connected to the Melter (See Note B)				
	200 VAC System (See Note C)	**220 VAC System**	**230 VAC System**	**240 VAC System**	**400 VAC System**
Automatic hose (0.6 m, 2 ft)	**45**	41	45	49	45
Automatic hose (1.2 m, 4 ft)	**100**	92	100	109	100
Automatic hose (1.8 m, 6 ft)	**155**	141	155	169	155
Automatic hose (2.4 m, 8 ft)	**205**	188	205	223	205
Automatic hose (3 m, 10 ft)	**265**	242	265	289	265
Automatic hose (3.6 m, 12 ft)	**315**	288	315	343	315
Automatic hose (4.8 m, 16 ft)	**420**	384	420	457	420
Automatic hose (7.2 m, 24 ft)	—	581	635	691	635
Manual hose (2.4 m, 8 ft)	**205**	188	205	223	205
Manual hose (4.8 m, 16 ft)	**420**	384	420	457	420
H-201 gun (T or T-L)	125	128	140	152	140
H-202 gun (T or T-L)	**210**	192	210	229	210
H-204 gun (T or T-L)	235	237	260	283	260
H-208 gun (T or T-L)	365	371	405	440	405
H-202 gun (T-E or T-E-L)	330	307	335	365	335
H-204 gun (T-E or T-E-L)	320	320	350	381	350
H-202 gun (T-LP or T-LP-L)	170	169	185	201	185
H-204 gun (T-LP or T-LP-L)	260	261	285	310	285
H-208 gun (T-LP or T-LP-L)	350	357	390	424	390
H-20 gun (T or T-L)	**180**	124	135	147	135
H-20 gun w/micro (T)	150	146	160	174	160

NOTE A: This table lists the power requirements for only the most common Nordson hoses and guns. If you do not find the hose or gun you are using, contact your Nordson representative for wattage information.

B: Actual line voltage in a plant may vary from nominal voltage by as much as ±15%. To calculate the actual power requirements at other line voltages, use the following formula:

$$PL = PN \times \left[\frac{EL}{EN}\right]^2$$

In this formula, PL is the wattage at line voltage, PN is the wattage at nominal voltage, EL is the line voltage, and EN is the nominal voltage.

C: The wattages in bold-face type are for hoses or guns specifically designed for 200 VAC operation.

Calculating Hose/Gun Capacity (contd.)

3. Compare the total wattages you calculated in step 2 to the maximum allowable wattages in Table D 1-4. If any wattage is exceeded, then the hose/gun configuration must be modified, either by changing the configuration or by changing the hoses and guns used. An example follows Table D 1-4.

Table D 1-4 Maximum Allowable Wattages for a Single Component, a Hose/Gun Pair, and a Power Module

Item	200 VAC System	220 VAC System	230 VAC System	240 VAC System	400 VAC System
Maximum for a single component (one hose or one gun)	870 W	957 W	1000 W	1043 W	1000 W
Maximum for a hose and gun pair (one hose and one gun)	1071 W	1179 W	1233 W	1286 W	1233 W
Maximum for a power module (two hoses and two guns)	1740 W	1913 W	2000 W	2086 W	2000 W

EXAMPLE: In the example from step 2, no hose or gun exceeds the single-component maximum of 1043 W (the closest is the 24 ft hose at 691 W).

Also, no hose/gun pair exceed the hose/gun pair maximum of 1286 W (the closest is in power module 3, where hoses and guns 5 and 6 each equal 1131 W).

However, the total wattage of power module 3 exceeds the power module maximum of 2086 W. This problem can be solved by rearranging hoses and guns 4 and 6 between power modules 2 and 3 as shown in Table D 1-5. The changes are shown in italics.

Table D 1-5 Rearranged Hose/Gun Wattages for the Example Series 3700 System

Power Module	Hose or Gun Zone Number	Type of Hose or Gun	Wattage of Hose or Gun from Table D 1-3	Total Wattages
Power module 1	Hose 1	24 ft hose	691 W	974 W
	Gun 1	H-204 gun	283 W	
	Hose 2	24 ft hose	691 W	920 W
	Gun 2	H-202 gun	229 W	
Total wattage for power module 1				1894 W
Power module 2	Hose 3	6 ft hose	169 W	398 W
	Gun 3	H-202 gun	229 W	
	Hose 4	*24 ft hose*	*691 W*	*1131 W*
	Gun 4	*H-208 gun*	*440 W*	
Total wattage for power module 2				*1529 W*
Power module 3	Hose 5	24 ft hose	691 W	1131 W
	Gun 5	H-208 gun	440 W	
	Hose 6	*10 ft hose*	*289 W*	*572 W*
	Gun 6	*H-204 gun*	*283 W*	
Total wattage for power module 3				*1703 W*
Total wattage for all hoses and guns (sum of the total wattage for all power modules)				5126

4. The last step is to ensure that the total hose/gun maximum wattage is not exceeded. Compare the total wattage for all power modules, which you calculated in step 2, to the maximum allowable wattage in the *Total Hose/Gun Maximum (W)* column in Table D 1-8, D 1-9, D 1-10, D 1-11, or D 1-12, whichever is appropriate for your system. These tables are contained in the next section, *Power Data Tables*. If the combined power module wattage of your system exceeds the maximum allowable wattage, you will need to reconfigure your system or order different hoses or guns. Contact your Nordson representative for assistance. An example follows this step.

NOTE: The other data in the power data tables is for reference only.

Calculating Hose/Gun Capacity (contd.)

EXAMPLE: For the example melter from step 2, Table D 1-11 shows that the maximum allowable hose/gun wattage is 5386 W. The total wattage for the example melter is 5126 W, which does not exceed this limit. However, note C in Table D 1-11 indicates that the wattage for hoses and guns 1, 2, 5, and 6 must be less than 3300 W, which is exceeded in the example by power modules 1 and 3, which have a combined wattage of 3597 W. This problem can be solved by rearranging the hoses and guns between power modules 1 and 2 as shown in Table D 1-6. The changes are indicated in italics. After the rearrangement, power modules 1 and 3 have a combined wattage of 3232 W, which is less than the 3300 W limit.

Table D 1-6 Rearranged Hose/Gun Wattages for the Example Series 3700 System

Power Module	Hose or Gun Zone Number	Type of Hose or Gun	Wattage of Hose or Gun from Table D 1-3	Total Wattages
Power module 1	Hose 1	*6 ft hose*	*169 W*	*398 W*
	Gun 1	*H-202 gun*	*229 W*	
	Hose 2	24 ft hose	691 W	*1131 W*
	Gun 2	*H-208 gun*	*440 W*	
Total wattage for power module 1				*1529 W*
Power module 2	Hose 3	*24 ft hose*	*691 W*	*974 W*
	Gun 3	*H-204 gun*	*283 W*	
	Hose 4	24 ft hose	691 W	*920 W*
	Gun 4	*H-202 gun*	*229 W*	
Total wattage for power module 2				*1894 W*
Power module 3	Hose 5	24 ft hose	691 W	1131 W
	Gun 5	H-208 gun	440 W	
	Hose 6	10 ft hose	289 W	572 W
	Gun 6	H-204 gun	283 W	
Total wattage for power module 3				1703 W
Total wattage for all hoses and guns (sum of the total wattage for all power modules)				5126

Power Data Tables

Use the appropriate table in this section as directed in the previous procedure, *Calculating Hose/Gun Capacity.* Refer to Table D 1-7 to determine the appropriate table.

Table D 1-7 Guide for Determining Which Power Data Table to Use

Type of Electrical Service Connected to Your Melter	Appropriate Power Data Table to Use
200 VAC 1∅ 200 VAC 3∅ (without neutral)	Table D 1-8
220 VAC 1∅ 220 VAC 3∅ (without neutral) 380/220 3∅ (with neutral)	Table D 1-9
230 VAC 1∅ 230 VAC 3∅ (without neutral) 400/230 3∅ (with neutral)	Table D 1-10
240 VAC 1∅ 240 VAC 3∅ (without neutral) 415/240 3∅ (with neutral)	Table D 1-11
400 VAC 3∅	Table D 1-12

Power Data Tables *(contd.)*

Table D 1-8 Total Hose/Gun Maximum Wattages for 200 VAC 1∅ or 3∅ Systems (used primarily in Japan)

Melter Model (See Note A)	Hose/Gun Electrical Capacity	Type of Power	Total Hose/Gun Maximum (W)	Internal Component Power (W) (See Note B)	System Power Maximum (W)	Current	
						1∅ Amps 200 VAC	3∅ Amps 200 VAC
3100 PP	2	1, 3∅	1740	1303	3043	15	13
	4	1, 3∅	3480	1303	4783	24	21
3100 AC	2	1, 3∅	1740	1737	3477	17	15
	4	1, 3∅	3480	1737	5217	26	23
3400 PP	2	1, 3∅	1740	1530	3270	16	14
	4	1, 3∅	3480	1530	5010	25	22
3400 AC	2	1, 3∅	1740	1965	3705	19	16
	4	1, 3∅	3480	1965	5445	27	23
3400 DC	2	1, 3∅	1740	2153	3893	19	17
	4	1∅	3300	2153	5453	27	—
	4	3∅	3480	2153	5633		25
3500 PP	2	1, 3∅	1740	2135	3875	19	17
	4	1∅	3300	2135	5435	27	—
	4	3∅	3480	2135	5615	—	25
	6	3∅	5220	2135	7355	—	25
3500 DC	2	1, 3∅	1740	2758	4498	22	20
	4	1∅	2700	2758	5458	27	—
	4	3∅	3300	2758	6058	—	27
	6	3∅	5140 (C)	2758	7898	—	27
3700 PP	2	1, 3∅	1740	2891	4631	23	20
	4	3∅	3480	2891	6371	—	20
	6	3∅	5040 (D)	2891	7931	—	27

NOTE A: PP stands for piston pump, AC stands for AC gear pump, and DC stands for DC gear pump.

B: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.

C: The total hose/gun maximum wattage for hoses/guns 1, 2, 3, and 4 must not exceed 3400 W.

D: The total hose/gun maximum wattage for hoses/guns 1, 2, 5, and 6 must not exceed 3300 W.

Table D 1-8 Total Hose/Gun Maximum Wattages for 200 VAC 1∅ or 3∅ Systems (used primarily in Japan) *(contd.)*

Melter Model (See Note A)	Hose/Gun Electrical Capacity	Type of Power	Total Hose/Gun Maximum (W)	Internal Component Power (W) (See Note B)	System Power Maximum (W)	1∅ Amps 200 VAC	3∅ Amps 200 VAC
3700 DC	2	3∅	1740	3515	5255	—	20
	4	3∅	3480	3515	6995	—	23
	6	3∅	5040 (C)	3515	8555	—	27
3830 AC	2	1, 3∅	1740	2267	4007	20	17
	4	1∅	3200	2267	5467	27	—
	4	3∅	3480	2267	5747	—	25
3860 PP 3890 PP	2	1, 3∅	1740	2891	4631	23	20
	4	3∅	3480	2891	6371	—	20
	6	3∅	5040 (C)	2891	7931	—	27
3860 AC 3890 AC	2	3∅	1740	3326	5066	—	20
	4	3∅	3480	3326	6806	—	22
3860 DC 3890 DC	2	3∅	1740	3515	5255	—	22
	4	3∅	3480	3515	6995	—	23
	6	3∅	5040 (C)	3515	8555	—	27
3930 PP	2	3∅	1740	2853	4593	—	14
	4	3∅	3480	2853	6333	—	21
3930 AC	2	3∅	1740	3288	5028	—	16
	4	3∅	3480	3288	6768	—	22
3960 PP	2	3∅	1740	5159	6899	—	22
	4	3∅	3480	5159	8639	—	28
	6	3∅	5220	5159	10379	—	32
3960 DC	2	3∅	1740	5783	7523	—	23
	4	3∅	3480	5783	9263	—	31
	6	3∅	5220	5783	11003	—	35
AG-30 PP	2	1∅, 3∅	1740	2134	3874	19	17
	4	1∅	3180	2134	5314	27	—
	4	3∅	3480	2134	5614	—	25
	6	1∅	4960	2134	7094	35	—
	6	3∅	5220	2134	7354	—	32

NOTE A: PP stands for piston pump, AC stands for AC gear pump, and DC stands for DC gear pump.

B: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.

C: The total hose/gun maximum wattage for hoses/guns 1, 2, 5, and 6 must not exceed 3300 W.

Power Data Tables *(contd.)*

Table D 1-9 Total Hose/Gun Maximum Wattages for 220 VAC 1∅, 220 VAC 3∅ (without neutral), and 380/220 3∅ (with neutral) Systems (used primarily in Europe)

Melter Model (See Note A)	Hose/Gun Electrical Capacity	Type of Power (See Note B)	Total Hose/Gun Maximum (W)	Internal Component Power (W) (See Note C)	System Power Maximum (W)	Current		
						1∅ Amps 220 VAC	3∅ Amps 220 VAC	3∅ Amps 380/220 VAC
3100 PP	2	1, 3∅	1913	1576	3489	16	14	9
	4	1, 3∅	3826	1576	5402	25	22	17
3100 AC	2	1, 3∅	1913	2102	4015	18	16	10
	4	1, 3∅	3826	2102	5928	27	24	17
3400 PP	2	1, 3∅	1913	1851	3764	17	15	9
	4	1, 3∅	3826	1851	5677	26	23	17
3400 AC	2	1, 3∅	1913	2377	4290	20	17	11
	4	1∅	3500	2377	5877	27	—	—
	4	3∅	3826	2377	6203	—	25	17
3400 DC	2	1, 3∅	1913	2606	4519	21	18	12
	4	1∅	3300	2606	5906	27	—	—
	4	3∅	3826	2606	6432	—	25	17
3500 PP	2	1, 3∅	1913	2583	4496	20	18	12
	4	1∅	3300	2583	5883	27	—	—
	4	3∅	3826	2583	6409	—	25	17
	6	3∅	5739	2583	8322	—	25	20
3500 DC	2	1, 3∅	1913	3338	5251	24	21	12
	4	1∅	2700	3338	6038	27	—	—
	4	3∅ w/o N	3400	3338	6738	—	27	—
	4	3∅ w/N	3826	3338	7164	—	—	21
	6	3∅ w/o N	5313 (D)	3338	8651	—	27	—
	6	3∅ w/N	5739	3338	9077	—	—	21
3700 PP	2	1, 3∅	1913	3498	5411	25	22	16
	4	3∅	3826	3498	7324	—	22	17
	6	3∅ w/N	5213 (E)	3498	8711	—	27	—
	6	3∅ w/o N	5739	3498	9237	—	—	26

NOTE A: PP stands for piston pump, AC stands for AC gear pump, and DC stands for DC gear pump.

B: W/o N means without neutral and w/N means with neutral.

C: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.

D: The total for hoses/guns 1, 2, 3, and 4 must be less than 3,400 watts.

E: The total for hoses/guns 1, 2, 5, and 6 must be less than 3,300 watts.

Continued on next page

Table D 1-9 Total Hose/Gun Maximum Wattages for 220 VAC 1∅, 220 VAC 3∅ (without neutral), and 380/220 3∅ (with neutral) Systems (used primarily in Europe) *(contd.)*

Melter Model (See Note A)	Hose/Gun Electrical Capacity	Type of Power (See Note B)	Total Hose/Gun Maximum (W)	Internal Component Power (W) (See Note C)	System Power Maximum (W)	Current		
						1∅ Amps 220 VAC	3∅ Amps 220 VAC	3∅ Amps 380/220 VAC
3700 DC	2	3∅	1913	4253	6166	—	22	19
	4	3∅	3826	4253	8079	—	24	19
	6	3∅ w/o N	5213 (D)	4253	9466	—	27	—
	6	3∅ w/N	5739	4253	9992	—	—	26
3830 AC	2	1, 3∅	1913	2743	4656	21	18	12
	4	1∅	3300	2743	6043	27	—	—
	4	3∅	3826	2743	6569	—	26	17
3830 AC	2	1, 3∅	1913	2743	4656	21	18	12
	4	1∅	3300	2743	6043	27	—	—
	4	3∅	3826	2743	6569	—	26	17
3860 PP	2	1, 3∅	1913	3498	5411	25	22	16
3890 PP	4	3∅	3826	3498	7324	—	22	17
	6	3∅ w/o N	5213 (D)	3498	8711	—	27	—
	6	3∅ w/N	5739	3498	9237	—	—	26
3860 AC	2	3∅	1913	4024	5937	—	22	18
3890 AC	4	3∅	3826	4024	7850	—	23	18
3860 DC	2	3∅	1913	4253	6166	—	22	19
3890 DC	4	3∅	3826	4253	8079	—	24	19
	6	3∅ w/o N	5213 (E)	4253	9466	—	27	—
	6	3∅ w/N	5739	4253	9992	—	—	26
3930 PP	2	3∅	1913	3452	5635	—	14	9
	4	3∅	3826	3452	7278	—	22	16
3930 AC	2	3∅	1913	3978	5819	—	17	10
	4	3∅	3826	3978	7804	—	23	16
3960 PP	2	3∅	1913	6242	8155	—	25	17
	4	3∅	3826	6242	10068	—	29	17
	6	3∅	5739	6242	11981	—	33	20
3960 DC	2	3∅	1913	6997	8910	—	25	17
	4	3∅	3826	6997	10823	—	33	21
	6	3∅	5739	6997	12736	—	36	21
AG-30 PP	2	1∅, 3∅	1913	2583	4496	20	18	12
	4	1∅	3260	2583	5843	27	—	—
	4	3∅	3826	2583	6409	—	25	17
	6	1∅	5220	2583	7803	35	—	—
	6	3∅	5739	2583	8322	—	33	20

NOTE A: PP stands for piston pump, AC stands for AC gear pump, and DC stands for DC gear pump.

B: W/o N means without neutral and w/N means with neutral.

C: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.

D: The total for hoses/guns 1, 2, 5, and 6 must be less than 3,300 watts.

E: The total for hoses/guns 1, 2, 3, and 4 must be less than 2,700 watts.

Power Data Tables *(contd.)*

Table D 1-10 Total Hose/Gun Maximum Wattages for 230 VAC 1∅, 230 VAC 3∅ (without neutral) (used primarily in North America), and 400/230 VAC 3∅ (with neutral) (used primarily in Europe) Systems

Melter Model (See Note A)	**Hose/Gun Electrical Capacity**	**Type of Power (See Note B)**	**Total Hose/Gun Maximum (W)**	**Internal Component Power (W) (See Note C)**	**System Power Maximum (W)**	**Current**		
						1∅ Amps 230 VAC	**3∅ Amps 230 VAC**	**3∅ Amps 400/230 VAC**
3100 PP	2	1, 3∅	2000	1723	3723	16	14	9
	4	1, 3∅	4000	1723	5723	25	22	17
3100 AC	2	1, 3∅	2000	2298	4298	19	16	10
	4	1, 3∅	4000	2298	6298	27	24	17
3400 PP	2	1, 3∅	2000	2023	4023	17	15	9
	4	1, 3∅	4000	2023	6023	26	23	17
3400 AC	2	1, 3∅	2000	2598	4598	20	17	11
	4	1∅	3500	2598	6098	27	—	—
	4	3∅	4000	2598	6598	—	25	17
3400 DC	2	1, 3∅	2000	2848	4848	21	18	12
	4	1∅	3300	2848	6148	27	—	—
	4	3∅	4000	2848	6848	—	26	17
3500 PP	2	1, 3∅	2000	2823	4823	21	18	12
	4	1∅	3300	2823	6123	27	—	—
	4	3∅	4000	2823	6823	—	26	17
	6	3∅	6000	2823	8823	—	26	21
3500 DC	2	1, 3∅	2000	3648	5648	25	21	12
	4	1∅	2500	3648	6148	27	—	—
	4	3∅ w/o N	3400	3648	7048	—	27	—
	4	3∅ w/N	4000	3648	7648	—	—	21
	6	3∅ w/o N	5400 (D)	3648	9048	—	27	—
	6	3∅ w/N	6000	3648	9648	—	—	21
3700 PP	2	1, 3∅	2000	3823	5823	25	22	17
	4	3∅	4000	3823	7823	—	22	17
	6	3∅ w/o N	5300 (E)	3823	9123	—	27	—
	6	3∅ w/N	6000	3823	9823	—	—	26

NOTE A: PP stands for piston pump, AC stands for AC gear pump, and DC stands for DC gear pump.

B: W/o N means without neutral and w/N means with neutral.

C: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.

D: The total for hoses/guns 1, 2, 3, and 4 must be less than 3,400 watts.

E: The total for hoses/guns 1, 2, 5, and 6 must be less than 3,300 watts.

Continued on next page

Table D 1-10 Total Hose/Gun Maximum Wattages for 230 VAC 1∅, 230 VAC 3∅ (without neutral) (used primarily in North America), and 400/230 VAC 3∅ (with neutral) (used primarily in Europe) Systems *(contd.)*

Melter Model (See Note A)	Hose/Gun Electrical Capacity	Type of Power (See Note B)	Total Hose/Gun Maximum (W)	Internal Component Power (W) (See Note C)	System Power Maximum (W)	Current		
						1∅ Amps 230 VAC	3∅ Amps 230 VAC	3∅ Amps 400/230 VAC
3700 DC	2	3∅	2000	4648	6648	—	22	20
	4	3∅	4000	4648	8648	—	25	20
	6	3∅ w/o N	5300 (D)	4648	9948	—	27	—
	6	3∅ w/N	6000	4648	10648	—	—	26
3830 AC	2	1, 3∅	2000	2998	4998	22	19	13
	4	1∅	3300	2998	6298	27	—	—
	4	3∅	4000	2998	6998	—	26	17
3860 PP	2	1, 3∅	2000	3823	5823	25	22	17
3890 PP	4	3∅	4000	3823	7823	—	22	17
	6	3∅ w/o N	5300 (D)	3823	9123	—	27	—
	6	3∅ w/N	6000	3823	9823	—	—	26
3860 AC	2	3∅	2000	4398	6398	—	22	19
3890 AC	4	3∅	4000	4398	8398	—	24	19
3860 DC	2	3∅	2000	4648	6648	—	22	20
3890 DC	4	3∅	4000	4648	8648	—	25	20
	6	3∅ w/o N	5300 (D)	4648	9948	—	27	—
	6	3∅ w/N	6000	4648	10648	—	—	26
3930 PP	2	3∅	2000	3773	5773	—	15	9
	4	3∅	4000	3773	7773	—	22	17
3930 AC	2	3∅	2000	4348	6348	—	17	11
	4	3∅	4000	4348	8348	—	24	17
3960 PP	2	3∅	2000	6823	8823	—	26	17
	4	3∅	4000	6823	10823	—	30	17
	6	3∅	6000	6823	12823	—	33	21
3960 DC	2	3∅	2000	7647	9647	—	26	17
	4	3∅	4000	7647	11647	—	33	21
	6	3∅	6000	7647	13647	—	36	21
AG-30 PP	2	1∅, 3∅	2000	2823	4823	21	18	12
	4	1∅	3300	2823	6123	27	—	—
	4	3∅	4000	2823	6823	—	26	17
	6	1∅	5340	2823	8163	35	—	—
	6	3∅	6000	2823	8823	—	33	21

NOTE A: PP stands for piston pump, AC stands for AC gear pump, and DC stands for DC gear pump.

B: W/o N means without neutral and w/N means with neutral.

C: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.

D: The total for hoses/guns 1, 2, 5, and 6 must be less than 3,300 watts.

Power Data Tables *(contd.)*

Table D 1-11 Total Hose/Gun Maximum Wattages for 240 VAC 1∅, 240 VAC 3∅ (without neutral), and 415/240 VAC 3∅ (with neutral) (used primarily in the British Commonwealth) Systems

Melter Model (See Note A)	Hose/Gun Electrical Capacity	Type of Power (See Note B)	Total Hose/Gun Maximum (W)	Internal Component Power (W) (See Note C)	System Power Maximum (W)	Current		
						1∅ Amps 240 VAC	3∅ Amps 240 VAC	3∅ Amps 415/240 VAC
3100 PP	2	1, 3∅	2086	1876	3962	17	14	9
	4	1, 3∅	4172	1876	6048	25	22	17
3100 AC	2	1, 3∅	2086	2502	4588	19	17	10
	4	1∅	3900	2502	6402	27	—	—
	4	3∅	4172	2502	6674	—	24	17
3400 PP	2	1, 3∅	2086	2203	4289	18	15	9
	4	1, 3∅	4172	2203	6375	27	23	17
3400 AC	2	1, 3∅	2086	2829	4915	20	18	12
	4	1∅	3600	2829	6429	27	—	—
	4	3∅	4172	2829	7001	—	25	17
3400 DC	2	1, 3∅	2086	3101	5187	22	19	13
	4	1∅	3300	3101	6401	27	—	—
	4	3∅	4172	3101	7273	—	26	17
3500 PP	2	1, 3∅	2086	3074	5160	22	19	13
	4	1∅	3300	3074	6374	27	—	—
	4	3∅	4172	3074	7246	—	26	17
	6	3∅	6258	3074	9332	—	26	22
3500 DC	2	1,,3∅	2086	3972	6058	25	22	13
	4	1∅	2500	3972	6472	27	—	—
	4	3∅ w/o N	3400	3972	7372	—	27	—
	4	3∅ w/N	4172	3972	8144	—	—	21
	6	3∅ w/o N	5486 (D)	3972	9458	—	27	—
	6	3∅ w/N	6258	3972	10230	—	—	22
3700 PP	2	1, 3∅	2086	4163	6249	26	23	17
	4	3∅	4172	4163	8335	—	23	17
	6	3∅ w/o N	5386 (E)	4163	9549	—	27	—
	6	3∅ w/N	6258	4163	10421	—	—	26

NOTE A: PP stands for piston pump, AC stands for AC gear pump, and DC stands for DC gear pump.
B: W/o N means without neutral and w/N means with neutral.
C: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.
D: The total for hoses/guns 1, 2, 3, and 4 must be less than 3,400 watts.
E: The total for hoses/guns 1, 2, 5, and 6 must be less than 3,300 watts.

Continued on next page

Table D 1-11 Total Hose/Gun Maximum Wattages for 240 VAC 1∅, 240 VAC 3∅ (without neutral), and 415/240 VAC 3∅ (with neutral) (used primarily in the British Commonwealth) Systems *(contd.)*

Melter Model (See Note A)	Hose/Gun Electrical Capacity	Type of Power (See Note B)	Total Hose/Gun Maximum (W)	Internal Component Power (W) (See Note C)	System Power Maximum (W)	Current		
						1∅ Amps 240 VAC	3∅ Amps 240 VAC	3∅ Amps 415/240 VAC
3700 DC	2	3∅	2086	5061	7147	—	23	21
	4	3∅	4172	5061	9233	—	26	21
	6	3∅ w/o N	5386 (D)	5061	10447	—	27	—
	6	3∅ w/N	6258	5061	11319	—	—	26
3830 AC	2	1, 3∅	2086	3264	5350	22	19	14
	4	1∅	3300	3264	6564	27	—	—
	4	3∅	4172	3264	7436	—	27	17
3860 PP 3890 PP	2	1, 3∅	2086	4163	6249	26	23	17
	4	3∅	4172	4163	8335	—	23	17
	6	3∅ w/o N	5386 (D)	4163	9549	—	27	—
	6	3∅ w/N	6258	4163	10421	—	—	26
3860 AC 3890 AC	2	3∅	2086	4789	6875	—	23	20
	4	3∅	4172	4789	8961	—	25	20
3860 DC 3890 DC	2	3∅	2086	5061	7147	—	23	21
	4	3∅	4172	5061	9233	—	26	21
	6	3∅ w/o N	5386 (D)	5061	10447	—	27	—
	6	3∅ w/N	6258	5061	11319	—	—	26
3930 PP	2	3∅	2086	4108	6194	—	15	9
	4	3∅	4172	4108	8280	—	23	17
3930 AC	2	3∅	2086	4734	6820	—	17	11
	4	3∅	4172	4734	8906	—	25	17
3960 PP	2	3∅	2086	7429	9515	—	27	18
	4	3∅	4172	7429	11601	—	31	18
	6	3∅	6258	7429	13687	—	34	22
3960 DC	2	3∅	2086	8327	10413	—	27	18
	4	3∅	4172	8327	12499	—	34	21
	6	3∅	6258	8327	14585	—	37	22
AG-30 PP	2	1∅, 3∅	2086	3074	5160	22	19	13
	4	1∅	3300	3074	6374	27	—	—
	4	3∅	4172	3074	7246	—	26	17
	6	1∅	5440	3074	8514	35	—	—
	6	3∅	6258	3074	9332	—	34	22

NOTE A: PP stands for piston pump, AC stands for AC gear pump, and DC stands for DC gear pump.

B: W/o N means without neutral and w/N means with neutral.

C: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.

D: The total for hoses/guns 1, 2, 5, and 6 must be less than 3,300 watts.

Power Data Tables *(contd.)*

Table D 1-12 Total Hose/Gun Maximum Wattages for 400 VAC 3∅ (used primarily in France) Systems

Melter Model (See Note A)	Hose/Gun Electrical Capacity	Type of Power	Total Hose/Gun Maximum (W)	Internal Component Power (W) (See Note B)	System Power Maximum (W)	Current (3∅ Amps 400 VAC)
3100 PP	2	3∅	1000	1507	2507	4
3400 PP	2	3∅	2000	2239	4239	7
	4	3∅	2000	2239	4239	7
3500 PP	2	3∅	2000	3125	5125	8
	4	3∅	2000	3125	5125	8
	6	3∅	2000	3125	5125	8

NOTE A: PP stands for piston pump.

B: The internal component power is the combined wattage of any of the following components your melter has: a tank, a motor, a grid, and a reservoir.

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REPORT ON THE RHEOLOGICAL CHARACTERIZATION OF
THREE EVA AND EVA/FERRITE COMPOUNDS

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Submitted on:

August 26, 2005

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INTRODUCTION

About half pound of each material were received by PPI on August 24, 2005. They were designated as follows:

(1) EVA MI 400 with 28% VA;
(2) EVA/FERRITE CTG CMPD Pellets;
(3) 75% Ferrite/25% EVA MI400 @ 28% VA.

EXPERIMENTAL PROCEDURE

The shear rate dependence of viscosity was obtained using the Instron Capillary Rheometer at 230 °C (446°F) using a capillary die with 0.0301" diameter and length of 2.0012". No usual flow instability was observed at all shear rates.

EXPERIMENTAL RESULTS AND DISCUSSION:

The actual data and the computed data obtained for the EVA MI 400 are tabulated in the Table 1 and plotted in Figure 1. The true viscosity vs. true shear rate for the material was calculated by assuming no slip at the wall and negligible entrance effect. The material exhibit the Newtonian fluid behavior.

The true viscosity and apparent viscosity obtained for the EVA/FERRITE CTG CMPD Pellets are tabulated in Table 2, and plotted in Figure 2. The upward trend at low shear rate range is typical behavior of all suspension materials.

The true viscosity and apparent viscosity obtained for the 75%FERRITE and 25% EVA MI 400 @ 28% VA are tabulated in Table 3, and plotted in Figure 3.

Comparison of the true viscosity obtained for the three EVA materials is shown in Figure 4.

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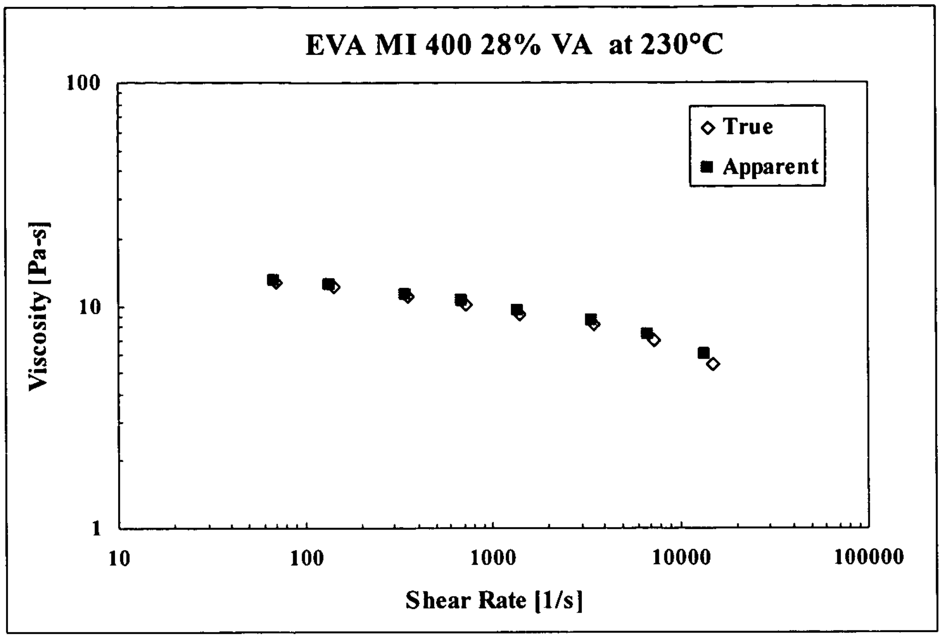

Figure 1. Viscosity of EVA MI 400 28% VA at 230°C

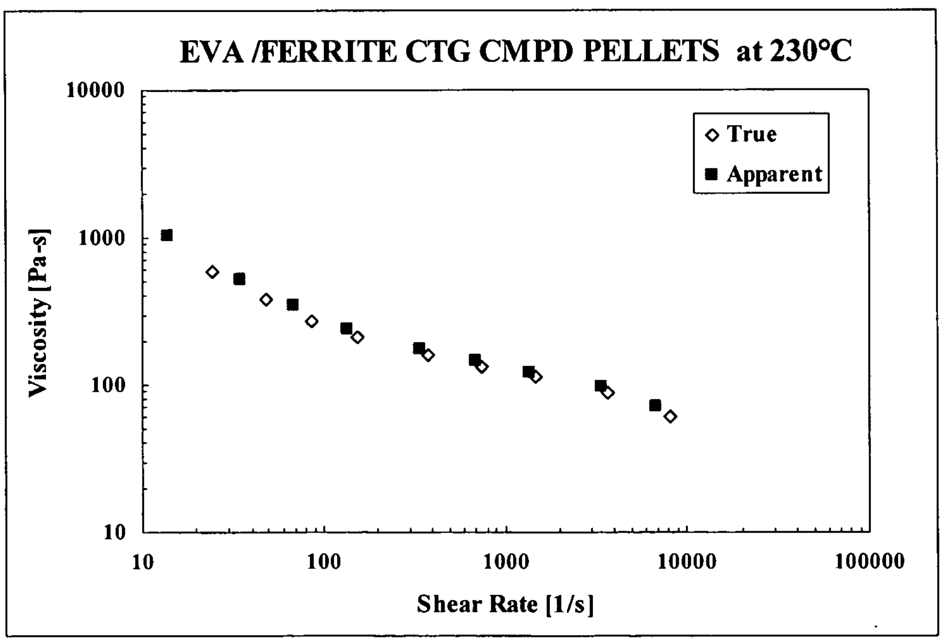

Figure 2. Viscosity of EVA/FERRITE CTG CMPD Pellets at 230°C

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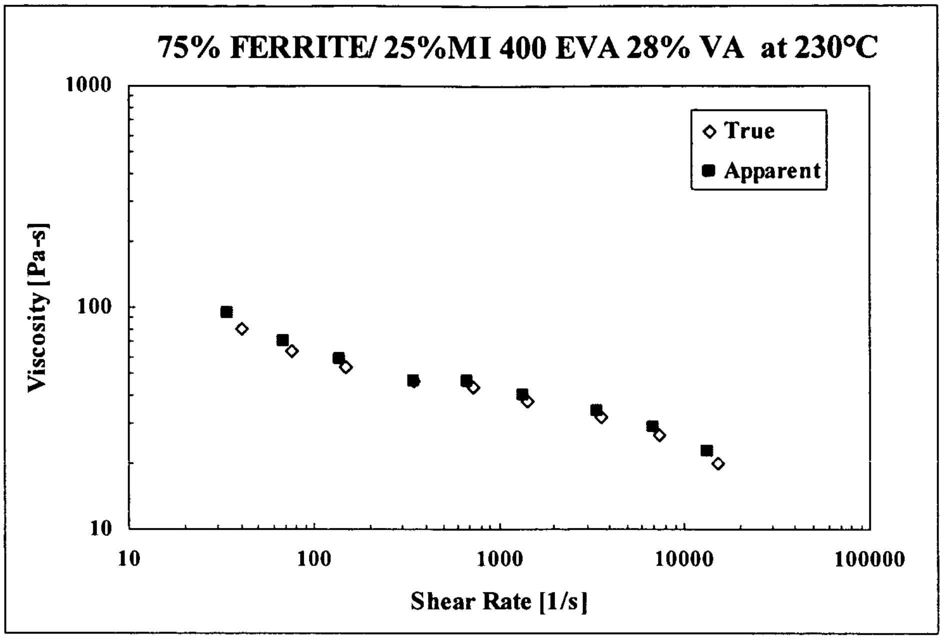

Figure 3. Viscosity of 75% FERRITE/25% EVA MI 400 28% VA at 230°C

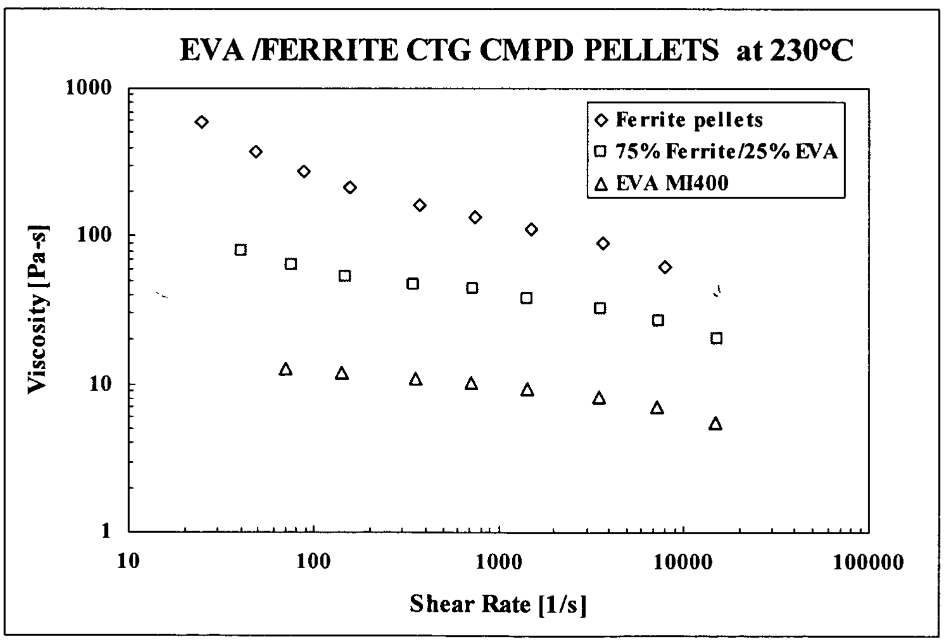

Figure 4. Comparison of True Viscosity of the Three Materials at 230°C

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Table 1. Viscositry of EVA MI400 28% EVA at 230 °C (446°F)

Speed [in/min]	Die #1 Force [lb]	Shear Stress w/o corr. [Pa]	Apparent Shear Rate [1/s]	Apparent Viscosity [Pa-s]	True Shear Rate [1/s]	True Viscosity [Pa-s]
0.10	3.8	8.924E+02	68.7	12.99	70	12.79
0.20	7.3	1.714E+03	137.5	12.47	142	12.07
0.50	16.4	3.851E+03	343.6	11.21	352	10.95
1.00	30.9	7.257E+03	687.3	10.56	718	10.10
2.00	55.6	1.306E+04	1375	9.50	1420	9.20
5.00	125.0	2.936E+04	3436	8.54	3549	8.27
10.00	217.0	5.096E+04	6873	7.42	7314	6.97
20.00	353.6	8.304E+04	13745	6.04	15187	5.47

Table 2. Viscositry of EVA/Ferrite CTG CMPD at 230 °C (446°F)

Speed [in/min]	Die #1 Force [lb]	Shear Stress w/o corr. [Pa]	Apparent Shear Rate [1/s]	Apparent Viscosity [Pa-s]	True Shear Rate [1/s]	True Viscosity [Pa-s]
0.02	61.2	1.437E+04	13.7	1045.64	25	584.56
0.05	76.3	1.792E+04	34.4	521.46	48	375.62
0.10	100.1	2.351E+04	68.7	342.06	87	270.07
0.20	140.0	3.288E+04	137.5	239.20	156	210.36
0.50	253.0	5.942E+04	343.6	172.91	374	158.82
1.00	422.0	9.910E+04	687.3	144.20	743	133.36
2.00	712.0	1.672E+05	1375	121.65	1496	111.77
5.00	1401.0	3.290E+05	3436	95.75	3740	87.97
10.00	2103.0	4.939E+05	6873	71.86	8086	61.07

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Table 3. Viscositry of 75% Ferrite + 25% 400 MI EVA at 230 °C (446°F)

	Die #1	Shear Stress	Apparent	Apparent	True	True
Speed	Force	w/o corr.	Shear Rate	Viscosity	Shear Rate	Viscosity
[in/min]	[lb]	[Pa]	[1/s]	[Pa-s]	[1/s]	[Pa-s]
0.05	13.7	3.217E+03	34.4	93.63	41	79.00
0.10	20.4	4.791E+03	68.7	69.71	75	63.77
0.20	33.8	7.938E+03	137.5	57.75	148	53.48
0.50	67.7	1.590E+04	343.6	46.27	343	46.40
1.00	136.5	3.206E+04	687.3	46.64	738	43.46
2.00	233.3	5.479E+04	1375	39.86	1448	37.83
5.00	496.0	1.165E+05	3436	33.90	3621	32.17
10.00	841.6	1.976E+05	6873	28.76	7407	26.68
20.00	1324.0	3.109E+05	13745	22.62	15566	19.98

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Meter, Mix and Dispensing Equipment: Basic Designs

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Many formulations of reactive adhesives require mixing of the resin and hardener in a critical ratio. This chapter deals with the basic designs of equipment for this purpose.

The most popular meter, mix and dispensing machines have been designed around *gear pumps* and *pistons*, or a combination of both. This chapter will explain how both systems function, their strengths and weaknesses.

In order to select a machine, several questions must be answered:

1. What material is to be dispensed: epoxy, polyurethane, silicone, etc.?
2. What are the characteristics of that material which will affect metering: viscosity (rheology), component ratio, filled or unfilled, abrasive or nonabrasive, pot life?
3. Application, production rate, volume required, continuous or intermittent dispensing?

THE GEAR PUMP SYSTEM

The circuit diagram in Fig. 1 shows the common gear pump metering system. The degree of sophistication governing the driving and monitoring of these devices varies from manufacturer to manufacturer, as does the cost.

In Fig. 1, the letters A and B represent the supply tanks. Tank A is usually the resin supply and Tank B the hardener supply. These tanks can vary in size from one quart up to 55 gallons. They may be ASME tanks which are capable of handling pressures to 75–80 psi. The tanks may be heated or cooled and may incorporate agitators, driven by electric or air motors.

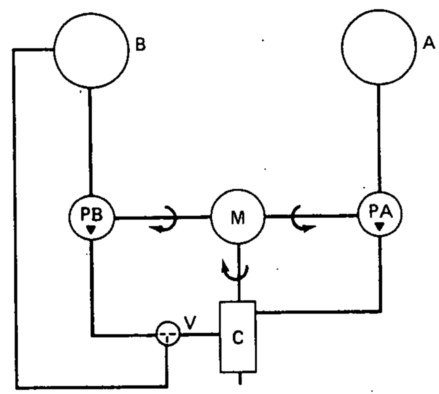

Fig. 1. Gear pump metering circuit. PA—resin metering pump; PB—hardener metering pump; V—three-way valve; M—drive motor; C—mixer. A—resin tank, B—Hardener tank.

The tanks may be equipped with liquid level controls which sense the amount of material in a tank. These sensors will send a signal, causing a pumping device to start filling the tank. Upon reaching a predetermined liquid level, a sensor will signal the filling device to stop. A system such as this makes the machine com-

pletely self-sufficient so long as the main material supply is maintained.

The letters PA and PB represent the metering pumps. These pumps are fixed displacement type, using either gears, diaphragm, or piston to displace the material being pumped. Only gear pumps and piston pumps will be covered, as diaphragm pumps are not popular.

Gear pumps vary in the precision with which they pump material against a resistance. The machine designer selects a specific pump according to the characteristics of the material being processed and the production requirements. Materials having viscosities, 500 cps and up, do not require the precision of pumps that pump materials with viscosities in the 50–500 cps range. Pump speeds (rpm) must be such that pump cavitation will not occur.

Gear pumps are very accurate metering devices and when used properly can do an excellent job. They cannot, however, be used with materials containing abrasive fillers, or highly filled materials which will prevent lubrication of moving parts. The filler material will cake up in the pump, causing the pump to jam. On the other hand, materials which have relatively high viscosity, but are still pumpable, cause the pump to run at near 100% efficiency since slip is at a minimum.

The advantage of the gear pump system (Fig. 1) is its simplicity. The system contains no check valves. It may contain a three way valve (V) to divert hardener from the mixer to the tank for the purpose of ratio checking or purging the mixer with resin.

The letter M denotes the drive of the pumps. This could be a simple gear head motor linked to the pumps via gears or chain and sprocket. It could also use a SERVO motor drive system. With this setup, ratio may be changed at will. With gears or sprockets, these must be physically changed in order to effect a change in ratio.

The letter C denotes the mixer of the machine. The two most popular types are the *dynamic* and the *motionless* mixer.

The Dynamic Mixer

This mixer is simply a rotating (usually bladed) agitator within a chamber. The space between the tip of the blades and the inside diameter of the mixing chamber is very small. Usually, part A (resin) will enter the chamber behind the part B (hardener) entry port. In some cases, a check valve is used to prevent the intrusion of resin into the B side of the machine as the result of a drop in B side system pressure. If this occurs, the valve closes, preventing part A from entering.

The mixer is driven by either electric or air motor; mixer speeds vary from 1700 up to 20,000 rpm.

Mixer shaft seals range from V-ring packings to mechanical rotary seals. The degree of back pressure and speed a mixer can tolerate is a function of mixer shaft seal type.

V-ring packings would require lubrication to extend the life of the seal, especially at high speeds and pressures. Mechanical (rotary) seals do not require lubrication, but have speed and pressure limitations, red lined by the manufacturer of the seal. Maximum speed for seals in the 0.500–0.625 in. shaft diameter range is about 4500 rpm at 100 psig system pressure.

The dynamic mixer can mix a variety of formulations since mixer speed, size, and resident time (the time the mixture spends in the mixing chamber) can be varied.

The disadvantages are that it does require maintenance, primarily cleaning and seal replacement. It cannot take high back pressure without premature shaft seal failure. In addition, being a mechanical device, it takes energy to drive; seals create frictional heat in addition to the heat generated by the shear action of the blades through the mixture. Mixing temperatures can exceed 120°F but this depends upon the rate of the material through the mixer and the temperature of the components being mixed. It should be noted that the gel time of the material being processed is no longer the published time and in all probability will be shorter due to the heat generated by the mixer. A good rule of thumb is: for every 10°C rise in temperature the pot life is reduced by one-half.

The Motionless Mixer

This mixer does not require mechanical energy to achieve the mixing of the two streams. Mix-

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Mix & Match

By Austin Weber / Senior Editor

The good things of life are not to be had singly, but come to us with a mixture." That statement, written in the early 19th century by Charles Lamb, a British essayist and poet, could easily apply to today's manufacturing environment.

More and more assemblers are turning to multicomponent adhesives for improved quality, productivity and efficiency. Acrylics, epoxies, silicones, urethanes and other adhesives have a number of performance properties often not available in single component materials.

For instance, two-part adhesives offer faster handling and cure times, and a variety of formulations to meet a growing number of applications. The rate of cure and cure characteristics are primarily controlled by the chemistry, whereas single-component adhesives rely on some part of the environment to cure.

Typically, the material cost of a dual component is higher, but the benefits in rate of cure, bond strength and application flexibility outweigh the cost difference. In many cases, multipart adhesives offer longer shelf life, without adverse effects on performance qualities.

"The two-part formulations typically can achieve properties that the single component material cannot," says Don Leone, director of sales and marketing at Ashby Cross Co. (Newburyport, MA). "Properties such as shrinkage, room-temperature cure, heat transfer ability, electrical insulation, chemical compatibility and adhesion are either not available or are not as desirable in a one-part adhesive."

However, there are disadvantages, such as the cost of equipment needed to process two-part materials. Indeed, automatic metering and mixing machines can cost $8,000 to $10,000 apiece, with robotic systems pushing the pricetag to $50,000 and up. But, if the

application is large enough, the cost of the equipment can easily be offset by the reduction in labor and the improvement in quality.

"Meter-mix systems are available from some manufacturers that can run as low as $3,000 to $4,000, but do not necessarily offer precise ratio control or long-term durability," says Todd Williams, sales manager at Sheepscot Machine Works (Newcastle, ME). "For applications that do not require stringent quality control, these systems may prove to be totally adequate.

"Often, however, these systems will not satisfy the rigid standards set by manufacturers whose products demand consistently high levels of quality," warns Williams. "The difference in cost can be as little as $600 or as much as $30,000 to $40,000, depending on the level of sophistication and automated features."

Growing Demand

According to a recent study conducted by The Freedonia Group Inc. (Cleveland), two-part reactive adhesives, such as epoxies and acrylics, are gaining ground in the automotive industry, largely at the expense of solvent-borne systems. As more composite materials, such as door panels and interior trim, are used to increase fuel economy and crash safety, adhesives are gaining more acceptance. Dual-component adhesives are usually less expensive and perform comparable to or better than mechanical fasteners or welding.

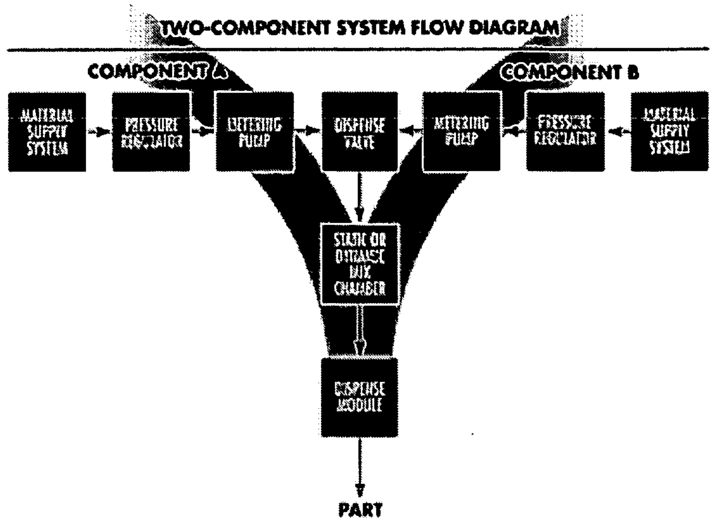
The electronics industry uses a wide variety of multicomponent adhesives as well. For instance, most potting and encapsulating applications for vibration protection, environmental protection or electrical isolation use two-part material. Flip chip bonding and fiber optics are also on the cutting edge of multicomponent adhesive technology.

Medical device manufacturers use multipart adhesives to assemble monitoring devices, patient support surfaces, patient implants and other products where clean, reliable bonding is required. Other heavy users of two-part material include cable manufacturers, filtration assemblers and yacht builders.

Freedonia Group researchers predict continued demand for multicomponent adhesives. In fact, epoxies, urethanes and other two-part formulations are expected to grow 3.9 percent a year during the rest of this decade.

As more manufacturers use multicomponent adhesives, demand for metering and mixing equipment has increased. "In any competitive situation, gaining control over quality and costs is paramount," says Williams. "Even in an economic downturn, manufacturers need to optimize all aspects of production in order to contain costs."

Manual vs. Machine



Meter-mix systems allow assemblers to correctly measure the amount of A and B material to achieve the right ratio. Illustration courtesy Nordson Corp.

Assemblers face unique challenges when blending and dispensing multicomponent adhesives. Correctly measuring the amount of A and B material so you have the right ratio is very important. Too much or too little can result in numerous headaches, such as inconsistent performance, poor quality and excessive cost. Fortunately, a wide variety of manual and automated systems is available.

Multicomponent adhesives can be mixed by hand, with a process similar to making cookie dough. Hand mixing requires weighing specific amounts of catalyst and base. After the two are measured, the mixing must be consistent to ensure correct curing. And, dispensing from a hand-mixed vessel can be awkward and wasteful.

"There are a lot of people out there who mix adhesives by hand," claims David Kirsch, product manager at ConProTec Inc. (Salem, NH). "The market is still full of small cans and jars of adhesive."

"For manufacturers who are trying to prototype a new product or initiate limited production runs, hand mixing is often utilized and can be somewhat cost effective," says Williams. How-ever, he points out that hand mixing results in wasted material, operator exposure to potentially toxic materials, poor ratio control and subsequent curing anomalies.

"Hand mixing is unreliable, not repeatable and usually produces excess waste," adds Leone. "However, for applications requiring small amounts of adhesive, this is the preferred method to the expense of a meter-mix system." Hand mixing, depending upon the application, has a labor cost and an adhesive cost.

Automated metering, mixing and dispensing systems offer an alternative to hand mixing. They provide precise ratio control, improved mixing, little or no wasted material and limited exposure to toxics.

"Meter-mixing equipment allows easy, consistent mixing of material," says Jeremy Richardson, technical manager for Accumetric LLC, John W. Blair Div. (Elizabethtown, KY). "The application staff does not have to weigh or measure. Instead, the machine ensures the correct ratio and mixers attached to the machine ensure correct mixing without the air entrapment experienced with hand mixing."

A less expensive alternative to meter-mixing equipment is dual-cartridge dispensing, which uses handheld dispensing guns. The easy-to-use plastic cartridges isolate the user from the material, the material is on ratio and mixing is achieved by a static mixer.

"This process is as easy as dispensing a tube of household caulk," claims Richardson. Cartridges eliminate the need for expensive meter-mix equipment while maintaining the principles of meter-mix. Because dual cartridges are very mobile, they're ideal for field applications. Capacities range from 50 to 1,500 milliliters, but most assemblers prefer 200- or 400-milliliter cartridges. Cartridges typically can't be reused and must be disposed of.

Another option often overlooked by assemblers is premixed, frozen adhesives. "The mixture is brought to a homogenous blend, placed into a syringe or other form of container, and immediately brought to a temperature of -90 to -100 F," says Jere Donohue, CEO of Intelligent Dispensing Systems Inc. (Encino, CA). "This immediately suspends any chemical reaction that is needed for material cure."

Frozen containers are packed in dry ice and shipped overnight to the end user. Thaw occurs by a warm water bath, microwave, hot air or other means that will bring the material to a workable and dispensable consistency. Donohue says premixed and frozen adhesives are typically used for small-dot applications common in the electronics industry. It eliminates the need for repeated batch mixing.

"Barrier packs are another good alternative for two- and three-component materials," explains Donohue. Barrier and injection systems are used mostly where there is a resin- or curative-type material.

Barrier cartridges have a foiled mixer dasher that is held in place inside the cartridge with a cinch tape on the outside of the cartridge. The resin and curative are separated by the foil. Injection systems consist of a cartridge filled with resin and an injection rod that contains the curative. The ramrod is pushed or jolted against a rod piston, compressing the material and causing the rod valve to rupture, injecting the curative into the resin.

Mixing Methods

Mixers can be either static or dynamic. Static mixers have no moving parts. They contain fixed, geometrically shaped elements that act as flow-splitting and shear-energy-creating devices for the materials that travel through them. Static mixers are usually either plastic or metal. They work well if the ratio and viscosity ranges of the two materials to be mixed are not too wide.

Static mixers serve as inline mixers--the components to be mixed are pumped through the mixer and emerge out the end totally mixed. They can be used with both two-component machines and cartridge applications.

"Disposable static mixers are more popular than they were 5 years ago, because of the proliferation of two-component materials," says Mark Murphy, product manager, Sulzer Chemtech USA Inc. (Deer Park, TX). "Health and environmental issues, such as worker exposure to the materials themselves and the solvents needed to clean them off hands, tools and equipment, have also contributed."

While static mixers have been around since the 1960s, the technology has changed very little over the years. One of the newest developments is a disposable mixer featuring a square-element geometry based on computer simulation. Murphy claims the pressure drop of the Sulzer Quadro is much lower than helical-type mixers with the same dimensions.

In dynamic mixers, materials are rotated with an auger or paddle within a mixing chamber by means of rotary air, electric or hydraulic motors. "In dynamic mixing, the material passes into a chamber with a rotating element," says Leone. "Higher mixing nd shear is created, providing better mixing."

Most dynamic mixers must be thoroughly cleaned after use, which takes time and exposes workers to hazardous waste. Typically, these mechanical mixers require solvent flush of the chamber. However, Leone says a hybrid dispense head is available that combines dynamic mixing with solvent-free mix chambers.

Metering Devices

A metering unit is essential for accurate volumetric dispensing of multicomponent adhesives. Meters help dispense precise volumes of adhesive at precise time intervals and pressures. The ratio and flow rate can be fixed or variable.

A pump is used to transfer adhesive from a point of supply, such as a 5-gallon pail, a 55-gallon drum or a 300-gallon tote, to a dispense head. A wide variety of pumping technology and equipment choices is available.

"Shot-based systems include piston pumps and rod pumps," says Dan Bradshaw, business manager at Liquid Control Corp. (North Canton, OH). "Continuous-flow systems include gear pumps and progressive cavity pumps. You have to define the accuracy needed for your application."

Gear pumps generally give the greatest accuracy, but for most applications, piston and rod systems work great and are less expensive. The advantages or disadvantages of each system usually depend on the type of adhesive being dispensed. Properties such as viscosity, specific gravity, mix ratio, sheer sensitivity and chemistry filler dictate the correct system to use.

Gear pumps are positive displacement devices that provide continuous flow with the ability to control flow rate. They work well

in applications where high, continuous flow is required, such as bead dispensing utilizing X-Y motion. Precision gear pumps usually will not tolerate formulations with fillers or abrasive content, as they tend to wear the metering components quickly. Gear pumps typically cost more than other metering methods.

Piston pumps are the most universally applied method of metering. They are versatile, reliable and repeatable. Two basic types are available: single-acting and double-acting. Capital outlay tends to be less than with gear pumps. Piston pumps also can be configured to handle abrasive, filled materials. Pneumatics are often used to move the fluid, so flow rates tend to vary slightly. However, servo drives can be used instead of pneumatics if the application requires it.

Rod pumps are used primarily in applications with a high abrasive content. They rely on blind metering, so there are fewer seals to wear than traditional piston metering. But, a limited range of bore sizes is available. Rod pumps also require lots of cycles to achieve a given volume.

Progressive cavity pumps are similar to an Archimedes screw rotating within a fixed cylinder. Material fills the voids in the screw and is transported through the cylinder. As the screw speed increases, flow rate also increases. However, progressive cavity pumps require compensating devices or controls due to the constant wear of internal volumetric components.

Mike Fornes, two-component product line manager at Nordson Corp. (Amherst, OH), estimates that gear and piston pumps account for approximately 60 percent of the market, followed by rod and progressive cavity pumps.

Current Trends

As assemblers demand more control and statistical feedback from their processes, meter-mix manufacturers are responding with increased levels of sophistication in system controls. Indeed, there are more options available today than ever.

"Technology has allowed meter-mix equipment to become increasingly complex," says Accumetric's Richardson. "For instance, varied shot size, vacuum degassing, heated tanks, multiple drum feeding systems, X-Y-Z function and PLC compatibility are all options on today's equipment."

Recent developments include:

- Bar code scanning to preset dispense parameters, even in mixed lots. It permits mixed groups of parts to be processed on the same line, where the bar code allows the meter-mix system to automatically preset the exact shot size, flow rate and other parameters.
- Vacuum impregnation systems for high voltage components to eliminate "corona" effects (arcing of high voltage through a void).
- Closed-loop control that provides real-time monitoring of flow rate and subsequent rate control modulation to maintain

consistent, stable flow.

- Better, easier-to-use operator interfaces, such as touchscreens, with different access levels for assemblers, engineers and maintenance personnel.
- Fail-safe devices, such as pressure transducers, to monitor pumps, power supply and other critical factors that can affect mixing ratios and dispensing conditions.
- Servo-controlled bead dispensing, crucial to integration of fluid dispensing with X-Y automated motion.

"Much of the control technology being applied to other meter-mix systems is used to compensate for design weaknesses such as ratio drift, racking and excessive wear of wet seal components," says Sheepscot's Williams. "When the design focus is on intuitive mechanical layout and tight mechanical tolerances, the results are elimination of backlash, improved repeatability, increased durability and, ultimately, less need for the lights and whistles."

Some vendors are attempting to fill the void between economical cartridge systems and expensive meter-mix machines. For instance, ConProTec is developing a point-of-application metering system featuring a pneumatically driven, positive displacement pump, a backpack to hold the adhesive supply and a handheld dispenser. According to Kirsch, the company is currently testing the system and expects to have something on the market later this year priced somewhere between $3,000 to $5,000.

Common Mistakes

Although a wide range of adhesive blending options is available, assemblers don't always choose the best system to match their needs. "With meter-mix equipment, there's no such thing as one-size-fits-all," says Carl Schultz Jr., vice president of Sealant Equipment & Engineering Inc. (Plymouth, MI). "It's an unfortunate lesson that too many people learn the hard way. You don't learn about metering, mixing and dispensing in college."

Lack of a preventive maintenance program is the biggest mistake assemblers make with metering, mixing and dispensing equipment. "It's a major problem," says Liquid Control's Bradshaw. "Too many people don't pay attention to their equipment. It's important to replace wear items, check the seals and check for contamination."

"Make a commitment to implement and support a good preventive maintenance policy," warns Williams. "Poor maintenance procedures are sure to bring on premature downtime. Mixing plural component adhesives can be a messy business, and if the equipment is allowed to run down, poor attitudes will follow."

Bradshaw, Williams and other experts urge assemblers to design good production procedures before installing meter-mix equipment. Sloppy production procedures and failure to enforce the procedures will yield poor results. Procedures should include checking fluid levels at appropriate intervals--every day if necessary; taking mixed material samples for quality control before initiating production runs; and designating responsible personnel who will monitor and remedy problems as they occur.

Assemblers should also avoid making the following mistakes:

- Designating the "lowest guy on the totem pole" to be responsible for the system. This often leads to poor maintenance procedures and a loss of production time.
- Selecting a resin that is not necessarily the most user or process friendly. While it may satisfy the product requirements, it also may impose unnecessary problems in production.
- Allowing a meter-mix system to run out of material. This introduces air into the system, one of the most common troubleshooting issues. Air displaces fluid, causing off-ratio metering, incomplete curing of material, and air infusion and voids in the mixed product.
- Crossing two materials on the machine. "Your meter-mix equipment will turn into a boat anchor," warns Richardson.
- Leaving material in the mixing chamber too long. Multicomponent adhesives typically have a short work life. Adhesive can start to cure on the perimeter of the mixer. As it builds up, it inhibits the mixing. To prevent clogs, automatic purge cycles should be programmed into dispensing equipment.
- Allowing material to sit out exposed to excess light, heat, cold or other potentially harmful environmental conditions.

When searching for a new adhesive material or supplier, be sure to consider how the meter-mix system will fit into the equation. "Many manufacturers address a new produc-tion requirement by first looking at resins," laments Williams. "Logically, they choose a resin based primarily on its ability to satisfy the production requirements, such as tensile strength, elasticity, heat dissipation qualities or flame resistance, without any thought as to how easy or difficult it may be to process in a meter-mix system.

"Only after they have gone through exhaustive testing of samples and submitted them for approval do they then consider the equally important process of how to best deliver the resin into the product," adds Williams. "Ideally, the search should simultaneously consider both criteria."

By using this approach, end users might discover that a number of resins may be suitable for the application, but the one with the less abrasive filler, such as calcium carbonate vs. aluminum oxide, will impact their preventive maintenance cycle less. Or, the product with a closer mix ratio--for instance, 2-to-1 vs. 10-to-1--will process more easily, causing fewer rejects.

"Abrasive products inevitably demand higher maintenance cycles," concludes Williams. "And closer mix ratios can generally be processed more easily than wide ratios."

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